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Fact or Fiction?: An Opera Singer's Piercing Voice Can Shatter Glass

Can the high C of a trained soprano quiver glass into dissolution?

By Karen Schrock on August 23, 2007



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The orchestra crescendos as a woman of ample proportions strides to the front of the stage, blonde braids trailing from under a horned helmet. Her gilded

bosom heaves as she inhales, opens her lipsticked maw and lets loose an earthshaking high note. Champagne flutes shatter, monocles crack and the chandelier explodes as the power of her voice wreaks havoc on the concert hall. The scene is in countless cartoons and comedies, but is this parody based on reality? Can an opera singer really shatter glass?

Physics suggests that a voice should be able to break glass. Every piece of glass has a natural resonant frequency—the speed at which it will vibrate if bumped or otherwise disturbed by some stimulus, such as a sound wave—as does every other material on Earth. Glass wine goblets are especially resonant because of their hollow tubular shape, which is why they make a pleasant ringing sound when clinked. If a person sings the same tone as that ringing note—a high C in legend but in reality the matching pitch could be any note—the sound of her voice will vibrate the air molecules around the glass at its resonant frequency, causing the glass to start vibrating as well. And if she sings loudly enough, the glass will vibrate itself to smithereens.

"It's possible, but you have to be both good and lucky," says Jeffrey Kysar, a mechanical engineer at Columbia University who studies the different ways in which materials can fracture and fail. "Even if you could excite the cup, that doesn't guarantee it would break. Fracture depends on the size of the initial defects." So in order for a diva to successfully demolish a wine glass, she would have to fortuitously choose one with microscopic defects that are big enough to buckle under pressure.

Invisible cracks and chinks cover every material's surface but their size and location can vary wildly, according to Kysar. Wine glasses that look identical to the naked eye could have radically different fracture strengths, enabling some to withstand much higher levels of volume than others.

Volume is a key player in the glass shattering game, because the loudness of a sound is directly related to the extent it displaces air molecules. In essence, the

sound passes from molecule to molecule until it hits the glass. As Brunhilde sings louder, she is, in effect, pushing air at the glass harder. The effect is much like pushing a kid on a swing—the harder each shove, the sooner the kid will go over the top. But a strong shove has little effect unless it is timed so it matches the natural oscillation of the swing—just as a hopeful glass breaker must sing a note that matches the glass's resonant frequency.

The physics involved in the art of vocal destruction seem straightforward enough. But although stories of powerful singers shattering wine goblets, vases and eyeglasses abound, real instances of this feat are suspiciously missing from the historical record. The famous tenor Enrico Caruso was said to have had the ability, but after he died his wife denied these rumors. What gives?

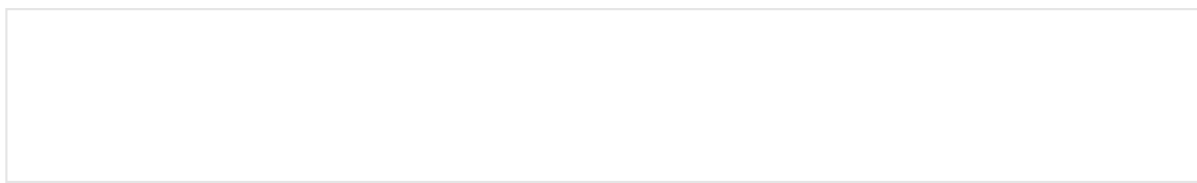
It turns out that most pieces of glass, including most wine glasses, are the equivalent of a kid on a swing who weighs hundreds of pounds. Push away, but that baby probably won't get anywhere close to the top.

Only the finest leaded crystal is dainty and resonant enough to break at volumes that some people can produce without amplification—upward of 100 decibels. A famous commercial from the 1970s showed Ella Fitzgerald shattering a wine glass with ease through Memorex speakers, and the trick has been repeated many times with amplification. The principle of directing sound at a brittle object is used, for example, to break up kidney stones—except doctors don't bother to find the resonant frequency, preferring just to blast the stone with lots of sound energy (and if a singer were as loud as, say, an explosion, she wouldn't have to find the resonant frequency to break a glass, either). Yet, it seems that until a couple of years ago there was no proof that any person had ever broken glass with his or her voice alone.

Then in 2005 the Discovery Channel television show *MythBusters* tackled the question, recruiting rock singer and vocal coach Jamie Vendera to hit some crystal ware with his best shot. He tried 12 wine glasses before stumbling on the

lucky one that splintered at the blast of his mighty pipes. For the first time, proof that an unassisted voice can indeed shatter glass was captured on video.

Vendera's glass-breaking wail registered at 105 decibels—almost as loud as a jackhammer. Not many people can muster the lung power for that kind of noise. Opera singers train for years to build up the strength to produce sustained notes at volumes above 100 decibels. (By comparison, typical speech is around 50 decibels.) Although I was trained as an opera singer before becoming a science journalist, I have never personally witnessed the phenomenon or been able to recreate it myself. That's not to say I won't try again—but perhaps I should procure a horned helmet, gilded breastplate and, most importantly, good amplifying speakers first.



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